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The role of tides in ocean--ice-shelf interactions in the southwestern Weddell Sea

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A novel regional ocean-sea-ice model configuration is designed to investigate the mechanisms of ocean–ice-shelf-melt interactions in the Weddell Sea. It features explicit resolution of the cavities of eastern Weddell, Larsen and Filchner-Ronne ice-shelves (FRIS, at 1.5-2.5 km horizontal resolution), as well as of the adjacent continental shelves (~2.5 km) and deep open-ocean gyre (at 2.5-4 km), in presence of interannually-varying atmospheric and ocean boundary forcing as well as explicit ocean tides. Simulated circulation, water mass and ice-shelf melt properties compare overall well with available open-ocean and cavity observations, and simulated Weddell ice-shelf melting reveals large variability on tidal, seasonal and year-to-year timescales. The presence of ocean tides, investigated explicitly, is revealed to result in a systematic time-average enhancement of both the production of ice-shelf meltwater as well as its refreezing on ascending branches of especially the FRIS cavity circulation. This tide-driven enhancement of the melt-induced FRIS cavity circulation acts to increase net ice-shelf melting (by 50%, ~50 Gt/yr) and the meltwater export by the FRIS outflow, and modulates their seasonal and lower frequency variability. The tidal impact on ice-shelf melting is consistent with being primarily driven mechanically through enhanced kinetic energy of the time-varying flow in contact with the ice drafts. The dynamically-driven tide-induced melting is thereby to almost 90% compensated by cooling through meltwater produced, but not quickly exported from regions of melting in the Weddell cold-cavity regime. Ocean boundary layer thermal adjustment underneath ice drafts, minimizing departures from the in-situ freezing point, thus substantially dampens the impact of tides on Weddell ocean–ice-shelf interactions. Simulations furthermore suggest attendant changes on the open-ocean continental shelves, characterized by overall freshening and modest year-round sea-ice thickening, as well as a marked freshening of newly-formed bottom waters in the southwestern Weddell Sea.